IMPROVED TRAPS AND TECHNIQUES FOR THE STUDY OF EMERGING AQUATIC INSECTS[1]

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ABSTRACT: A description is given of floating pyramidal emergence traps which can be used in running and standing water and semi-aquatic habitats. They have a wood or ABS tubing base and the netting is fine muslin. There are two versions of the traps: Model DAY collects efficiently for a period of 24 hours or less and can be emptied rapidly as the whole net can be removed by a fast stripping method. Model WEEK permits samples to be taken over longer periods (2-15 days) and is suitable for taxonomic purposes, surveys over wide regions or studies of large lakes and rivers. Both models can be used for quantitative or qualitative limnological studies such as daily and seasonal emergence patterns, life tables and the effects of peculiar ecological factors. The construction, dimensions and the methods of setting the traps are described in detail and special problems, such as the frequency of emptying, water condensation, predators, and the criteria for the choice of models are discussed.

Mundie (1971) and Morgan (1971) review the literature on emergence traps for limnological studies; most traps are designed for standing water (Lindeberg 1953; Corbet 1965, Frank 1965, Mundie 1971, McCauley 1976) or wetlands (Lammers 1977) and cannot operate in lotic situations. Even the 3-sided pyramidal trap (Mundie 1964, 1966) or the stream box trap of Hamilton (1969) are overturned by spates or quickly plugged by large amounts of drifting detritus. The strong floating trap of Langford & Daffern (1975) is very resistant to spates and works well in running water but its size limits its use to large rivers.

Two types of traps are described, the first, Model DAY, designed to collect emerging insects for a period of 24 hours or less and, the second, Model WEEK, designed to collect for a period of up to one week. Both models could be used on wetlands, standing or running water under various weather conditions and are not selective for different groups of insects. New techniques have also been developed to reduce the time involved in the collecting and preservation of the trapped insects.

MODEL "DAY"

Construction

The base of the trap (Figs. 1a & 2) is made of 4 pieces of wood, 75 cm long, 7 cm wide, 1.5 cm thick, joined together; the free internal surface is

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0.37 m^2. Four strips of polystyrene ("styrofoam"), 10 cm wide and 5 cm thick are nailed underneath to give bouyancy. A strip of wood is fixed along the inner top edge of the base, shaped as in Fig. 1 for net attachment. Four wooden rods 1.5 cm diameter for holding the top plate are joined to the base and the plate by spiral (twisted) nails through drilled holes. The top plate is made of 1.5 cm plywood and is 15x15 cm. A hook in the middle of the plate

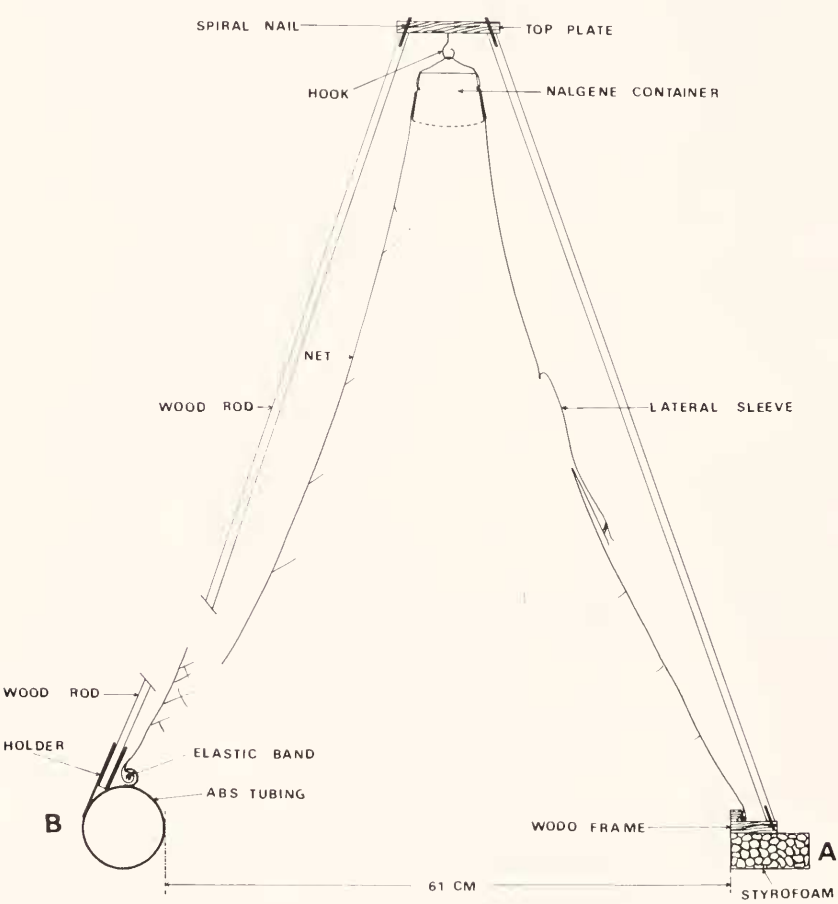

Figure 1. Cross section through a pyramidal floating trap showing parts. A–model DAY with wood frame, net and container. B–ABS tubing base for model WEEK.

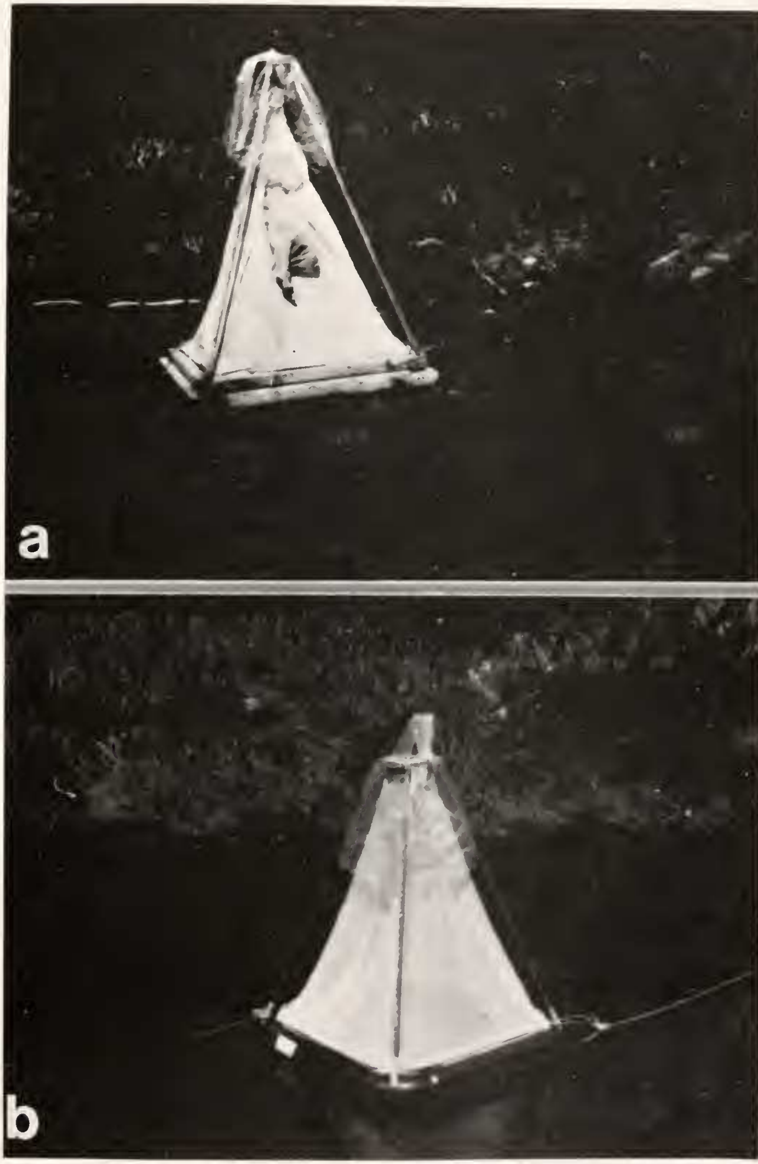

Figure 2. A–trap model DAY set in the field at Salem Creek, Elmira, Ontario. B–a trap model WEEK set over a pool.

holds the top of the net. A transparent plastic bag, covering the top one-third of the trap is stapled around the plate for protection against rain and wind.

The net is made of four panels of synthetic muslin (Tergal tissue-27 mesh/cm, opening of 240/cm. The panels are about the same size as the four sides of the frame but 1 cm extra is allowed on each side for stitching and the base of each panel is 1.5 cm wider than the frame so that the completed net can be easily put on and taken off the frame. A strong elastic band is threaded through the hem of the net to hold it in the groove formed by the basal strip of wood (Fig. 1a). The top of the net is fixed to a small Nalgene container with fiberglass tape. A cord, resistant to ethyl acetate, is used to hang the container and net to the frame.

Operation

This model is specially designed for fast processing of emerged insects. It has now been tested successfully over two years of daily collections and has also been emptied hourly for a study of diel emergence patterns.

The "stripping method", which is not affected by the number of insects in the net, can be summarised as follows:

A. To attach the net:

1. Hang the top Nalgene container to the frame.

2. Take the two far corners of the net, one in each hand (Fig. 3a).

3. Fix the far side of the net in the groove, pull the net towards you and secure the lateral and near sides (Fig. 3b).

B. To empty the traps:

4. Tap the base of the net to encourage any insects that may be resting there to move upwards. Remove the base of the net and hold it closed (Fig. 3c).

5. Detach the top of the net, turn the net upside down and shake 3 to 5 times to concentrate the insects in the top container (Fig. 3e). This step is optional as most insects will have already moved to the top, but advisable as small, fragile insects (Ceratopogonidae, Chironomidae, etc.) seem to be protected against eventual damage by next steps.

6. Introduce the upper half to two-thirds of the net gently, without packing, into a large killing bottle containing ethyl acetate and snap the cap (Fig. 3d). A useful killing bottle can be made from a large one-gallon jar with three paper towels moistened with ethyl acetate on the bottom. It was found convenient to use two such jars at a time so that another trap could be emptied while the insects from the first were being killed.

7. While insects are being killed (allow two minutes), re-set the trap with a spare net.

8. When insects are killed, remove the net from bottle and shake all of them down into the container (Fig. 3e).

9. Hold container in one hand and, with the other, turn the net completely inside out (Fig. 3f).

10. Empty the contents into a large funnel with a tube attached (Fig. 3g). A 30 cm diameter Nalgene funnel on a support is ideal and a 2.5 cm diameter plastic test tube fits snugly onto it.

11. Tap the funnel when working in dry conditions or wash down the organisms with 70% ethanol from a wash bottle, while holding the receiving tube with the other hand. Label each tube with the corresponding trap number.

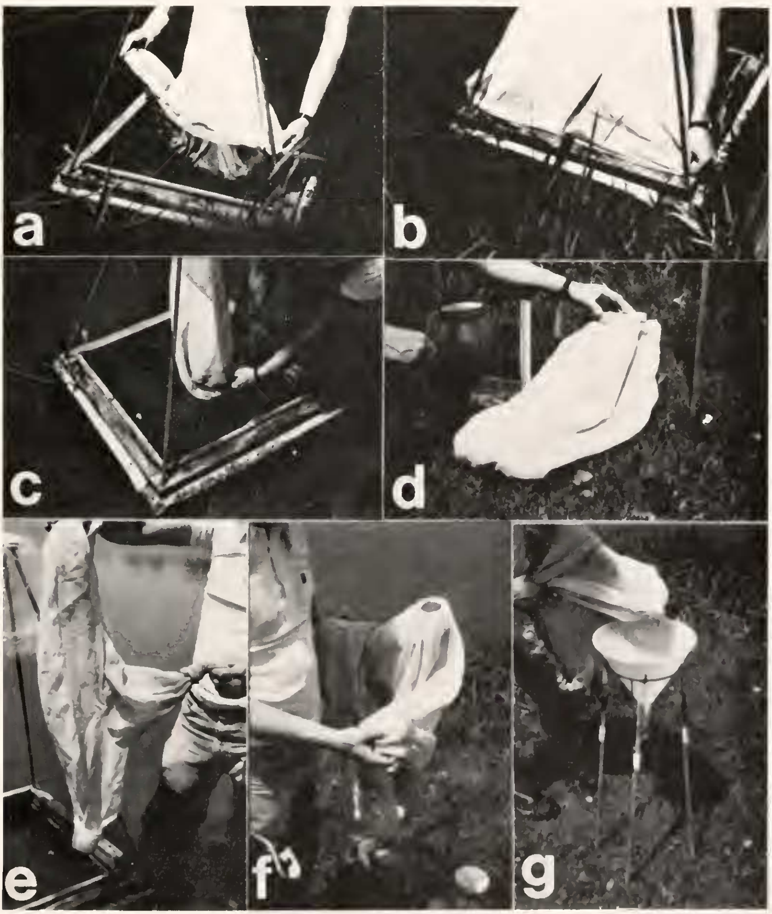

Figure 3. A–G Illustration of different steps of the stripping method for emptying traps model DAY. See the text for details.

12. The traps should be emptied at the same time each morning, or as soon after noon as possible, and always in the same order to obtain an accurate 24-h. emergence.

MODEL "WEEK"

Pyramidal version

Construction and dimensions correspond to model DAY but traps are more sturdy and the floating base is made from ABS drainage tubing (Figs. 1b, 2b). This base consists of four straight pieces, 10 cm diameter and 51 cm long joined into a square with all joints sealed and thoroughly waterproof. The groove for holding the base of the net is made from 2 cm diameter polychlorovinyl (PCV) tubing bonded to the top of the base with epoxy cement; the outer one-third of this tube is cut away (Fig. 1b). A small piece of the same PCV tubing is fixed upright at each corner to receive the rods supporting the net; however, as a satisfactory joint (ABS-PCV) is difficult to make, a stronger joint was obtained in later models from pieces of ABS folded into the shape required (by gentle heat) and glued with ABS cement. The rods are the same size as those used in model DAY. The net for model WEEK is almost the same as described for model DAY; the distinguishing feature is that it is made to fit on a collecting head instead of the container, and that the base of the net is fixed tightly by introducing a supplementary non-elastic cord in the hem to eliminate eventual blowing out of nets by strong gusts of wind.

Small collecting heads are made readily from transparent plexiglass and Nalgene bottles (Figs. 4, 5). The plexiglass base has an 8x8 cm aperture; holes are drilled in the 4 corners to take screws and one side is recessed to allow for the positioning of a Nalgene collecting bottle when the head is completed. The concentrator is attached above the base; this is made of four pieces of plexiglass (dimensions in Fig. 4) to form a long sloping side, a short vertical side and two triangular enclosing sides, shown. The vertical side has a 4x4 cm aperture near the top to allow insects to pass into the collector.

The collector consists of two Nalgene bottles each 12 cm high. One is fixed upside down, as shown, and has a lateral hole corresponding to that of the concentrator, the second one screws onto this and is replaceable. As Nalgene is difficult to glue, it is necessary to bolt the bottle to the lid and the side of the concentrator; these joints should be sealed with silicone cement. The attachment for the replaceable bottle is made of a Nalgene bottle cap pierced with as large a hole as possible; this has to be attached with screws to the fixed bottle and the replaceable bottle can be screwed into it.

The collecting head itself is attached by screws to a square wooden plate

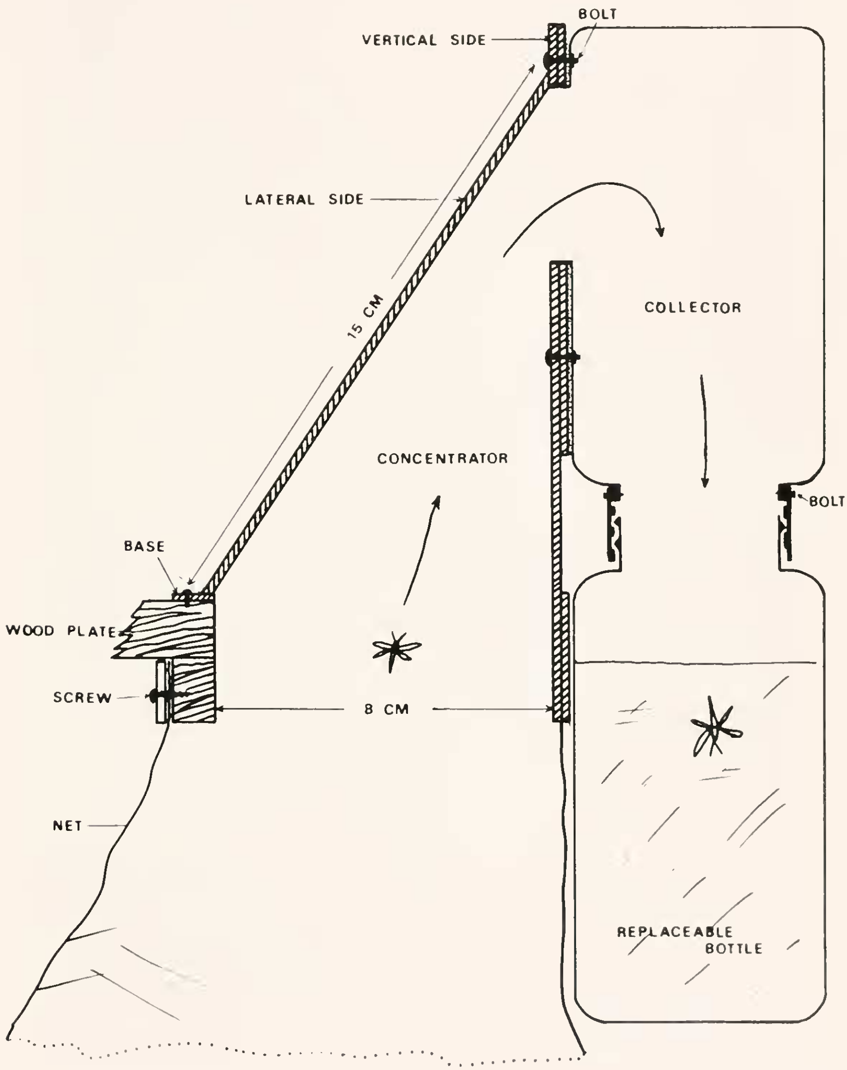

Figure 4. Cross section through a collecting head for model WEEK showing parts and hypothetical flight followed by trapped insects.

(15x15 cm), with an aperture of 8x8 cm, that is attached to the four rods fitting into the floating base as in model DAY. The net is the same as that used in model DAY but here the top of the net is fixed directly to the wooden plate by means of a small piece of wood attached by screws. A protecting plastic bag is stapled around the plate as in model DAY.

Operation

Insects can be collected rapidly merely by replacing bottles. Collecting bottles are 3/4-filled with a mixture of 2 parts of 70% alcohol to one part of commercial ethylene glycol. The volume of the preservative remained fairly constant for a week or more. Trapping efficiency is improved if 5 ml of dishwashing detergent is added to each liter mixture to lower the surface tension. The trap can be left for two weeks if 1:1 70% ethanol and ethylene glycol are used then a large collecting bottle must be employed. In the laboratory insects should be transferred to fresh 70% ethanol.

As spiders and other predators may give trouble it is recommended that nets be made with a lateral sleeve so that these can be removed at each visit.

Truncated version

It was observed in the field that some insects were clearly not caught by the collecting head just described and it was suspected that these species avoided the opening. It was decided, therefore, to construct a trap with an enlarged collecting head but with the same size of base. This was achieved by truncating the trap and fitting a head with a 20x20 cm aperture (Fig. 5b), that is an aperture more than 5x the previous model.

Although no large-scale test was carried out, the truncated version appeared to be more effective from field observations because the number of insects noted resting on the net was generally smaller, the larger aperture produced less shade, eventual obstruction by spiders webs was considerably reduced, and the dead floating insects observed sometimes under the pyramidal version were not present.

OBSERVATIONS, REMARKS AND COMPARISONS

Model DAY was used for two spring-fall seasons and model WEEK for one season for a study on the life cycles of stream chironomids in the Salem Creek near Elmira, Ontario; the results of this are to be published elsewhere. In this section field observations, and problems encountered in sampling are discussed and these traps compared with previously described ones.

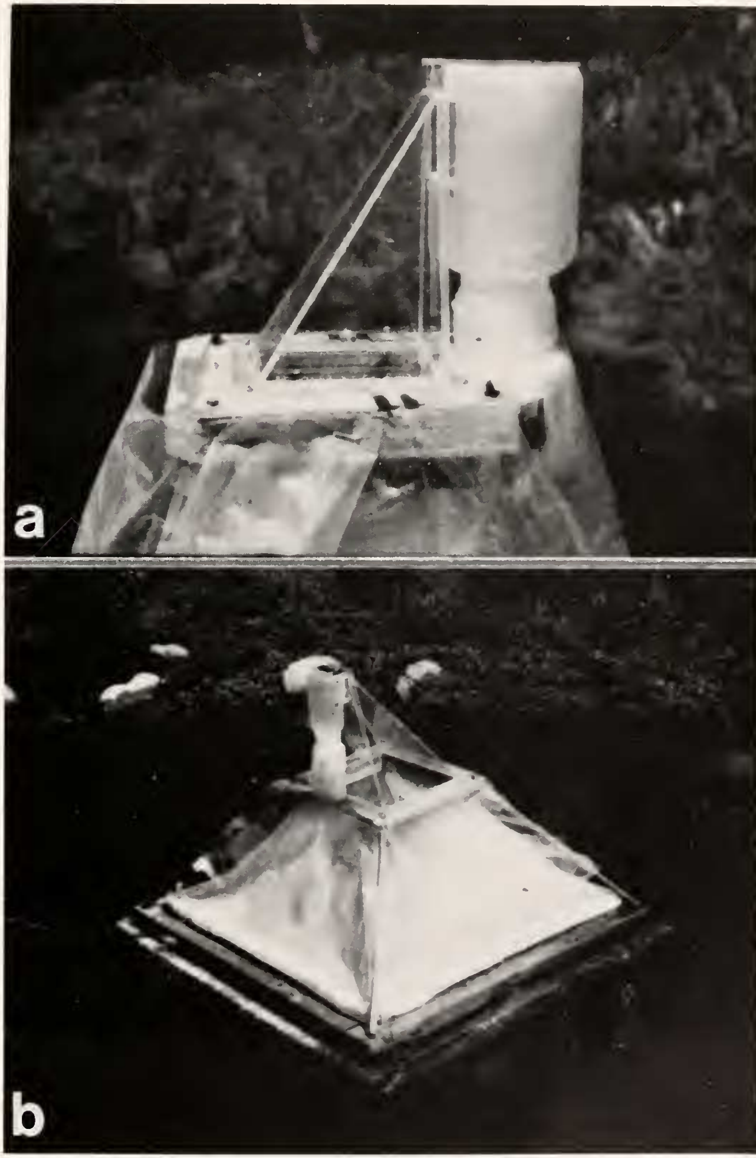

Figure 5. A–Close-up of a collecting head of trap model WEEK. B–Truncated version of trap model WEEK.

Construction

The material for both traps can be found in any general hardware store. The traps are easy to build and do not require special tools. No differences in efficiency were noted between those traps with a base of wood or those with ABS tubing. Model DAY costs about $20.00 (U.S. 1976) and model WEEK, with ABS tubing about $30.00 for material, labour not included. If limited funds are available, model WEEK can be made with a wooden base and any model WEEK can be adapted for daily use.

Styrofoam strips are eventually damaged after a year or so or loose their bouyancy and must be replaced. The ABS base is more durable and remains bouyant.

Shape

Traps with triangular, square, rectangular and round bases have been proposed (Mundie 1971, Morgan 1971); the shape is probably not important in standing water but in lotic situations traps must disturb the water flow as little as possible; the square base was found to be best adapted for this purpose, specially when anchored with one angle facing the current. The square base, furthermore, is more convenient for setting traps half on the bank and half in the water and altogether more versatile than the fixed box trap of Morgan (1971).

Size

Morgan, Wadell and Hall (1963) found a correlation between the size and efficiency of emergence traps in standing water; they concluded in their series that a base of 0.46 m^2 proved optimal and that one of 0.37 m^2 was the second best.

A base of 0.37 m^2 was adopted for our study for several reasons. First, the traps are not too bulky and not too heavy, an important factor for floating in running water. Second, the traps are not too large to be placed over a single substratum type, or a small secondary branch stream, without overlapping more than one microhabitat. Third, they are large enough not to interfere excessively with water flow in the area they enclose, and large enough to cover large objects such as tree stumps, rocks, piles of twigs, riparian vegetation, etc. Also they can be placed half in the water and half on the bank to sample the fauna of stream margins. The 0.37 m^2 size, therefore, seems to be a good compromise between the need for portability and convenience and the need for obtaining reliably large samples.

Net

The mesh must be less than 300 μm if all the insect fauna is to be collected (Morgan 1971); many Ceratopogonidae, Orthocladiinae and other small insects can escape through window screen or cotton gauze, often used (Needham 1908, Adamstone & Harkness 1932, Miller 1941, Scott & Opdyke 1941, Vallentyne 1952). Several synthetic curtain muslins are now available commercially, these are cheap, translucent, strong and finely meshed (openings of 200-250 μm) and ideal for emergence traps. After three years of use our nets are still in good condition.

Scott & Opdyke (1941), using floating tent traps, showed that those made of opaque material caught fewer insects than those made of white muslin. Our "Tergal" muslin nets are very pale blue and cut off very little light.

The fine muslin material also provides a good support for nymphs, subimagos and adults as they can easily grip it while moulting or maturing. Subimaginal and nymphal exuviae are often found on the net and are easily collected and preserved for eventual association with adults.

Setting in the field

Traps are secured so that they always sample at the same spot independent of water level fluctuations. In fast-flowing water traps do not move very much laterally but tend to sink in current over 2 m/s. Bouyancy is increased if the attachment rope is fixed high up on to a pole or a tree so that the angle between this rope and the water surface is 45° or more even during high water periods (Fig. 2b). The rope should be at least 2 m long to give the trap freedom to respond to changes in level and turbulence. It is suggested that the traps be fixed in position and their flotation tested during a spate or high spring levels if disasters and possible losses are to be avoided. It may be necessary to change the location of some traps or to attach supplementary bouys if the current is too fast. In pools or in standing water the efficiency of the traps may be reduced by their tendency to move in the wind (Morgan, Waddell & Hall 1963, Morgan 1971). They can be stabilized by driving poles around them to hold them steady or by extra anchors.

Frequency of emptying

The frequency of emptying the traps is probably the most important factor in any study of emergence. In most studies, even "quantitative" ones, traps are emptied every second day and sometimes after even longer periods (Hall, 1963, Morgan, Waddell & Hall, 1963, Macan 1964, Anderson & Wold 1972). Hamilton (1969) could find no significant differences between emptying daily and every second day. Nevertheless, in our studies in Salem Creek, insects left in the net for 24 h. after emergence showed a mortality of 81-100%, depending on the group of insects involved and the weather. All small insects were dead and dry and only larger specimens such as Trichoptera, Plecoptera, Ephemeroptera and Diptera still survived 48 h. later. When the wind was strong or the night cold all insects died.

During 500 days of daily emptying few dead animals were noticed floating on the water surface. In Salem Creek the emergence peak is after sunset or late afternoon for most insects and so these were resting or flying about the net for 10-15 hours as they were collected soon after noon the next day. It is estimated from dead insects found floating that model DAY and the net stripping emptying method account for more than 99% of emerged insects and are ideal for quantitative studies.

Condensation

In Ontario daily fluctuations in temperature throughout the collecting season can produce considerable quantities of dew in open plastic and glass containers. For this reason tent traps made of polyethylene (Sublette & Dendy 1959) are inappropriate in this climate. No serious condensation was found on the muslin netting and even small insects remained dry. Protection from rain and wind was provided by the plastic covering at the top of the trap.

Condensation problems in the collecting head of model WEEK were resolved by piercing vents through the sides of the concentrator or collector and covering them with muslin.

Predation by various invertebrates

In our study spiders were the most important predators but their deprivations were much reduced by daily emptying. Other predators such as the Gyrinidae, Gerridae and fishes probably preyed on some emerging insects but previous authors have considered these as a minor source of error (Morgan, et al. 1963). Spiders may become a serious problem when traps are emptied weekly as they tend to spin their nets over the entrance to the collecting head. Their influence is minimized when the larger head (20x20 cm) is used; the losses they cause can be roughly estimated by examining the webs for insects remains.

Dragonflies and Empidae do not have time to cause damage in the daily collecting program and soon fly into the bottle in model WEEK.

Special groups of insects

Living specimens are available for special studies; they can be picked out of the trap in the field or the whole net can be brought into the laboratory for processing.

Very small insects such as Ceratopogonidae, Orthocladiinae, etc., are collected successfully, specially by model DAY: the net stripping method of emptying is better for these than any other method described so far. Very short lived insects, such as the Tricorythidae are more easily sampled by model WEEK than model DAY, specially in the case of those species which will not rest on the muslin but fall into the bottle, nevertheless.

Dried specimens (Tabanidae, Tipulidae, Odonata, Coleoptera, etc.) may be obtained from both models. With model DAY they can be killed with either ethyl acetate or potassium cyanide prior to pinning and, in model WEEK the collecting bottle can be replaced with a deep version of a classical killing bottle with KCN. In this case bottles should be emptied often, daily if possible.

Semiaquatic groups, insects pupating on the banks or species that crawl to the shore to emerge can be collected by setting traps part on land and part over water or by setting them over special microhabitats such as log piles, small boulders, marginal vegetation and on sand and mud flats.

Choice of model

Each model has its advantages and limitations. Both are easy to build and sample nearly all kinds of microhabitats in running and standing water. The time involved in emptying is very short and independent of the number of specimens in the trap. As they both float they do not disturb the substratum underneath which can therefore be sampled over long periods.

The main advantage of model DAY is that it collects a 24-h. emergence efficiently; it is, therefore, recommended for quantitative or life-cycle studies. It is also very useful for the study of diel emergence patterns. The use of a number of traps together minimizes losses due to bad weather, spates, predators and cattle and gives data suitable for statistical interpretation.

Model WEEK is ideal for taxonomic purposes as specimens are well preserved and traps can be emptied rapidly. It is also useful when traps cannot be emptied daily, when only the general pattern of emergence is needed, or when a large area has to be surveyed. It is also more convenient for special situations such as deep lakes and large rivers and more effective than model DAY for trapping insects with a very short adult life.

The truncated version of model WEEK represents the best compromise when quantitative results are needed but time is not available for daily sampling. The large aperture reduces considerably any inhibitions insects may have against entering the collecting head and the time involved for emptying is only a few minutes at each visit.

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